2012 INTERNSHIPS AND TECHNICAL REPORTS

Great Lakes Research and Education Center
Indiana Dunes National Lakeshore, Porter, IN
February 14, 2012

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Preface

The National Park Service initiated the Natural Resources Challenge in 1999. The Challenge resulted in the funding and development of 19 Research Learning Centers (RLCs) throughout the country. The RLCs increase the effectiveness and communication of scientific research in national parks by 1) facilitating use of parks for scientific inquiry; 2) supporting science-based decision making; 3) communicating current research information; and 4) promoting resource stewardship through partnerships. RLCs initiate, support, and implement a wide variety of research projects and provide opportunities for university students to work with researchers and park managers. The Great Lakes Research and Education Center (GLREC) initiated a university student internship and technical support program in 2005 to provide research opportunities to scientists and managers in the Great Lakes Network parks (GLKN). Since 2005 the percentage of the GLREC budget allocated to the research internship program has ranged from 2-11%, depending on the number of requests from parks. Funded park requests has ranged from one to eight. From 2005 to 2012 the total GLREC funding allocated to the program during the 8-year period has been $131,300.

The internships and technical support are provided for natural and cultural research projects conducted during field season, usually May through September. The schedule for the interns' duty times varies by park needs. Students are selected based on established contacts with individual parks and universities. In the past, the internship program was advertised in the Great Lakes Northern Forest Cooperative Ecosystem Study Unit (CESU), RLC and park websites, as well as in websites of scientific organizations. Both undergraduate and graduate students are eligible to participate in the programs. Most students have found the program very valuable to their training. At the same time parks have obtained needed assistance for projects. One student commented, "One suggestion I can give is to continue the program and continue to expose more students to this program".

At the end of the internship, each student produces a standard report for the GLREC steering committee. A summary of the reports from the 2012 field season is presented in this document, including those from APIS, CUVA, GRPO, INDU, ISRO, PIRO, SLBE, and VOYA.

We wish to thank the GLREC steering committee for supporting and facilitating research opportunities for undergraduate and graduate students in the Great Lakes National Parks.

Joy Marburger, Research Coordinator　　　　Wendy Smith, Education Coordinator

Apostle Island National Lakeshore

Mapping historic farm vegetation at Sand Island

Project Title: Two Historic Farmstead Cultural Landscapes at Apostle Islands National Lakeshore: Archeological Site Condition Assessments

Report Authors/Affiliations: Nicholas Skulan, GLREC Intern, Ripon College, WI

Project Summary:
A GLREC-supported intern from Ripon College, Wisconsin spent twelve weeks conducting field and archival research at Apostle Islands National Lakeshore in support of cultural resource research efforts**.** The main project consisted of a cultural landscape study at two historic Norwegian immigrant farmsteads on Sand Island. The intern, supported by APIS staff and equipment, conducted field research on the Hansen and Noring farmsteads. This included GPS mapping of structures and historic vegetation, development of a narrative description of landscape resources, and development of a GIS base map. The intern also used park archives, recorded oral histories, historic and modern aerial photography, and written records to research the history and use of the farmsteads.

A second project included performing an archeological survey and condition assessment at 14 prehistoric and historic archeological sites in the park under the supervision of the APIS archeological technician and cultural resource specialist. The intern gained valuable field experience in archeological survey and testing methods, while the park obtained important data on the location and condition of archeological resources.

Personnel Involved: Nicholas Skulan (APIS/GLREC Intern), Lane Johnson (APIS Archeological Technician), David Cooper (APIS Cultural Resource Specialist)

Products and Deliverables:
Draft Cultural Landscape Inventory and Base Map (Hansen Farm, Sand Island)
Draft Cultural Landscape Inventory and Base Map (Noring Farm, Sand Island), Draft Archeological Site Condition Assessments (multiple islands)

Literature Cited:
Busch, Jane C. *People and Places: A Human History of the Apostle Islands*. National Park Service, Midwest Regional Office, Omaha, Nebraska, 2008.
Dahl, Frederick (editor). *Diary of a Norwegian Fisherman.* Paramount Press, Jacksonville, Florida, 1989.

Acknowledgements:
We would like to thank the GLREC for the financial assistance which made this project possible.

Budget:
GLREC internship stipend: $2,500; APIS in-kind: $5,420
Supplies $100 (APIS in-kind)
Boat operations (APIS in-kind 30 hrs @$100) $3,000
Ground transport (APIS in-kind) $100
GS-011 cultural resource supervisor (in-kind, 30 hours x $34) $1,020
GS-05 archeological technician (in-kind, 80 hours x $15) $1,200

Cuyahoga Valley National Park, Pictured Rocks National Lakeshore, and Sleeping Bear Dunes National Lakeshore

Fawn Pond, CUVA

Sand Point, PIRO

Westman Road, SLBE

Project Title: Improved DNA Screening Methods for Cattail Identification

Report Authors/Affiliations: Steven E. Travis, Ph.D./University of New England, Biddeford, ME; Justin Mascone, GLREC Intern, University of New England, Biddeford, ME

Project Summary:
Cattails have undergone a massive, albeit cryptic, North American expansion over the past hundred years (Galatowitsch et al. 1999) driven by a combination of environmental and evolutionary forces (e.g., Wilcox et al. 1985, Woo & Zedler 2002, Travis et al. 2010). Recently, work in my lab has revealed that hybridization between *T. latifolia* and *T. angustifolia* is an important factor contributing to cattail invasiveness, at least in the Great Lakes region (Travis et al. 2010). Initially, this work had to await the development of species-diagnostic molecular (DNA) markers for accurate species identification (Snow et al. 2010), given the overlapping morphologies that tend to confound pure and hybrid cattails (e.g., Kuehn and White 1999). Our early work was conducted in invaded wetlands located in Indiana Dunes National Lakeshore (INDU), St. Croix National Scenic Riverway (SACN), and Voyageurs National Park (VOYA), and clearly showed that hybrid *Typha x glauca* typically represent the largest clones in mixed *Typha* stands based on six species-diagnostic markers. More recently, we have examined cattail stands at Cuyahoga Valley National Park (CUVA), Pictured Rocks National Lakeshore (PIRO), and Sleeping Bear Dunes National Lakeshore (SLBE). Although the SLBE and PIRO stands appeared initially to represent a mixture of cattail species based on morphology, the CUVA stands appeared to consist entirely of hybrids, exhibiting the typical variable morphology and robust growth seen formerly in the pure hybrid stands at INDU. However, whereas the molecular genotyping of cattails at SLBE proved consistent with their morphology, both the PIRO and CUVA stands were genotyped as pure *T. latifolia*. This seeming inconsistency has led us to believe that our initial genetic screening may have failed to reveal hybrid ancestry owing to the introgression of *T. angustifolia* alleles into *T. latifolia* populations through repeated backcrossing following some long-ago hybridization event. Thus, the current project was aimed at developing at least four additional molecular markers to refine the evaluation of cattails in PIRO and CUVA, as well as in other parks and managed lands.

Personnel Involved:
Steven E. Travis, Associate Professor of Biology, University of New England
Justin Moscone, Research Assistant (GLREC Intern)

Products and Deliverables:
In our previous work (Snow et al. 2010), we screened eight microsatellite loci from among the 11 loci developed by Tsyusko-Omeltchenko et al. (2003) from the DNA of *T. angustifolia*, and found seven to be diagnostic of species. In the current study, we screened the remaining three loci from the Tsyusko-Omeltchenko et al. (2003) paper, and an additional four loci from a more recent paper by Csencsics et al. (2010) reporting the development of microsatellite markers from *T. minima*, or dwarf bulrush. Our screening was conducted from 70 archived samples we had previously identified as either pure *T. angustifolia* or pure *T. latifolia* (Snow et al. 2010). Unfortunately, none of the remaining unscreened Tsyusko-Omeltchenko et al. (2003) loci proved to be species diagnostic. On the other hand, two of the four markers we screened proved species-diagnostic, so we proceeded to bolster the earlier genotyping of our PIRO and CUVA samples using these new markers. We applied, for the first time, the seventh species-diagnostic marker

identified in Snow et al. (2010) to the PIRO and CUVA samples. Although results are currently only available for CUVA, our additional screening continues to indicate predominantly pure *T. latifolia* within this park, although introgression has been revealed for the first time in approximately 10% of the cattails sampled, and this number could continue to climb if additional species-diagnostic markers can be developed from the remaining 13 unscreened Csencsics et al. (2010) loci. The remaining unscreened locus from the Snow et al. (2010) paper, which was evaluated by Snow et al. (2010) using a much smaller sample size than all of the other markers, was revealed as non-species-diagnostic in our current study.

We suggest that the introgression of *T. angustifolia* genes into *T. latifolia* for populations in CUVA and PIRO via backcrossing may not be detected by the current 7-10 microsatellite diagnostic markers applied in the study. We suggest development of chloroplast DNA as well as additional nuclear markers.

The current work has not yet been publicly disseminated, but several posters on the results have been presented at various professional conferences.

Literature Cited:

Csencsics, D, S. Brodbeck, and R. Holderegger. 2010. Cost-effective, species-specific microsatellite development ofor the endangered dwarf bulrush (*Typha minima*) using next-generation sequencing technology. Journal of Heredity 101:789-793.

Galatowitwch, S. M., N.O. Anderson, and P.D. Ascher. 1999. Invasiveness in wetland plants in temperate North America. Wetlands 19:733-755.

Snow, A. A., S. E. Travis, R. Wildová, T. Fér, P. M. Sweeney, J. E. Marburger, S. Windels, B. Kubátová, D. E. Goldberg, and Evans Mutegi. 2010. Species-specific SSR alleles for studies of hybrid cattails (*Typha latifolia* x *T. angustifolia*; Typhaceae) in North America. American Journal of Botany 97:2061-2067.

Travis S.E., J.E. Marburger, S.Windels, and B. Kubátová. 2010. Hybridization dynamics of invasive cattail (*Typhaceae*) stands in the Western Great Lakes Region of North America: a molecular analysis. Journal of Ecology 98:7-16

Tsyusko-Omeltchenko-Omeltchenko, O., N. Schable, M. Smith, and T. Glenn. 2003. Microsatellite loci isolated from narrow-leaved cattail *Typha angustifolia*. Molecular Ecology Notes 3:535–538

Wilcox, D.A., K.P. Kowalski, H. Hoare, M.L. Carlson, and H. Morgan. 2008. Cattail invasion of sedge/grass meadows and regulation of Lake Ontario water levels: photointerpretation analysis of sixteen wetlands over five decades. Journal of Great Lakes Research 34:301-323.

Woo I. and J.B. Zedler. 2002. Can nutrients alone shift a sedge meadow towards dominance by the invasive *Typha x glauca*? Wetlands 22:509-21.

Acknowledgements:

I thank Joy Marburger (GLREC) and Steve Windels (Voyageurs National Park) for financial and logistical support, and M. Simon (NOAA-NERR Fellow, University of New England) for technical support. I also thank the NPS Water Resources Division and the GLREC for funding.

Budget: GLREC supplies: \$600; Water Resource Division (Joel Wagner): \$2,000.

Grand Portage National Monument

Title: Mapping of the Thompson's Ridge Archaeology Site

Report Authors/Affiliations: Brandon Seitz, cultural resource manager, and Susan Kilgore, GLREC Intern, University of Iowa, Dubuque, IA

Project Summary:
Susan Kilgore mapped the excavation units at the Thompson's Ridge archaeology site. Elevation data were obtained using a Topcon Autolevel and stadia rod and geospatial data were obtained with a Trimble Nomad GPS.

Personnel Involved: William Clayton, Chief of Resource Management, GRPO
Susan Kilgore (GLREC Intern)

Products and Deliverables:
Geospatial mapping of excavation units using GPS to obtain elevation surveys and creation of a geospatial map of excavation units at the Thompson's Ridge site. Data and map were delivered to the GRPO Chief of Resource Management, Bill Clayton prior to 01 September 2012.

Acknowledgements: Many thanks to William Clayton for this opportunity, and to Joy Marburger for support of this project

Budget: GLREC internship stipend, $600

Indiana Dunes National Lakeshore

Log jam in the Little Calumet River, Indiana Dunes National Lakeshore

Title: Evaluation of the Structural, Fluvial, and Biological Function of Logjams in the East Branch of the Little Calumet River within Indiana Dunes National Lakeshore

Report Authors/Affiliations: Jana C. Cram, Ivy Tech Community College, GLREC Intern; Dr. Erin P. Argyilan, Indiana University Northwest; Dr. Laurie S. Eberhardt, Valparaiso University; Dr. Charles C. Morris, Indiana Dunes National Lakeshore

Project Summary:
This project was conceived to assess the impact logjams have on the structural, fluvial, and biological functions of low-gradient streams like the section of the Little Calumet River which flows through the Indiana Dunes National Lakeshore (INDU). Analysis of the data collected will help inform decision-making on the removal of logjams on National Park property for recreational purposes.

Four logjam sites were selected for study in pairs, with one site to be a control and the other to be modified at a point in time after the data is collected. Sites chosen had no passable routes through the jam; that is, woody debris must be present across the entire width of the stream. It was also necessary that the sites be accessible to researchers and their equipment. These sites are located along the east branch of the Little Calumet River within INDU, specifically at: 41.62204N, 87.08926W (Site 1); 41.62124N, 87.09243W (Site 2); 41.62172N, 87.10073W (Site 3); and 41.61996N, 87.10532W (Site 4).

An interdisciplinary approach was taken in this study. In order to evaluate the waterway before and after logjams are removed, baseline data was collected on the geomorphological structure of the stream, which included water depth, stream-bed elevation, and depth of fines; its water chemistry and dynamics, which included temperature, flow rates, pH, and conductivity; and, biologically, its role as a habitat for aquatic life, which included fish monitoring and the collection and identification of benthic macroinvertebrates. Quantifying the amount of woody debris within the logjam was also a main concern.

Researchers designed and implemented a transect grid overlay system to evaluate woody debris volume and surface area, water depth, stream-bed elevation, and depth of fines at four separate logjam sites.Using the logjam itself as the central reference point of the survey site, a 20 meter zone was created (10 meters upstream and 10 meters downstream from the established reference point) and one meter^2 grids were created by running measuring tapes across the stream at one meter intervals. At each grid point, water depth, stream-bed elevation, and depth of fines was recorded using a surveyor's transit and transit rod. Within each grid box, every piece of woody debris was measured for diameter with tree calipers and for length with measuring tape. Reference points were marked with rebar to facilitate study replication next year.

Other measured parameters included pH, conductivity, and temperature using a Hydrolab Multiparameter Sonde at each site before starting the woody debris survey. Water temperature has also been constantly monitored since May, 2012, when Hobo data loggers were deployed at each logjam site. Water flow rate was monitored using a flowmeter at one meter intervals across the stream from points five and ten meters both upstream and downstream from the central reference point of the logjam.

Fish surveys were completed using long-line electroshocking techniques following the Indiana Department of Environmental Management's standard operating procedures. All fish were identified onsite and released.

Benthic macroinvertebrates were collected using a modified D-net method. Samples were taken from the five habitats identified at the logjam survey site with the Qualitative Habitat Evaluation Index ('QHEI'): sand, silt, wood, root wad, and root mat. Three 30-second D-netting efforts at each habitat were composited and retained for enumerations and family level taxonomy. Three Hester-Dendy plates were deployed at each site for six weeks; samples collected were identified for family level taxonomy.

The next phase of this project commenced with the modification of Site 2 and Site 4 on September 21 and 23, 2012. Water chemistry and turbidity were collected during the modification process. The study will resume in May, 2013, when the study methods outlined above will be replicated to collect post-modification data.

Personnel Involved:
Lead researcher Jana Cram (GLREC intern) was assisted by Dr, Charles Morris, Environmental Specialist at the Indiana Dunes National Lakeshore, as well as Dr. Erin Argyilan of Indiana University Northwest. and Dr. Laurie Eberhardt of Valparaiso University.

The logjam study field team also included Indiana Dunes National Lakeshore Water Quality Biotechnician Joshua Dickey and the following Student Conservation Association interns: Matthew Lewitke, Kelsie Rudolph, and Ryan Venturelli.

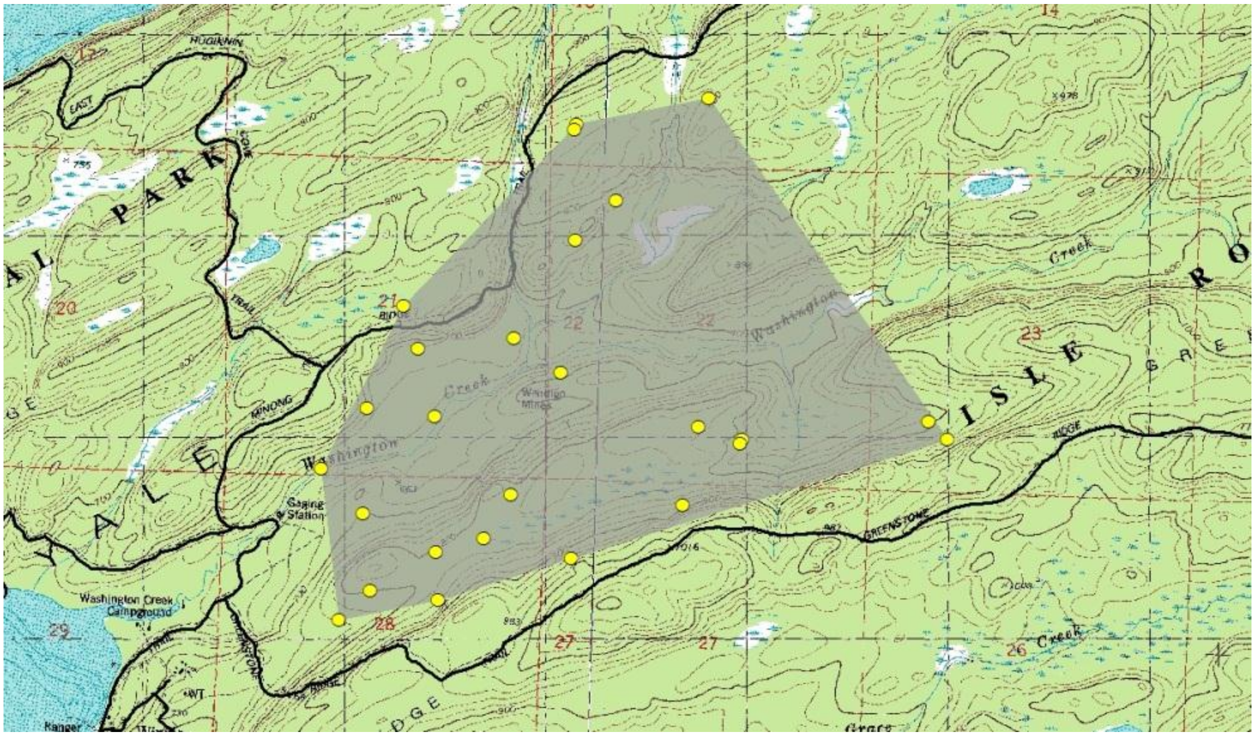
Macro-invertebrate D-netting was completed by Valparaiso University students Alexandra Olson and Halina Hopkins.

Products and Deliverables:
As of September 15, 2012, all pre-modification logjam data had been collected and is located at the GLREC Field Research Station in the Indiana Dunes National Lakeshore. For each of the four logjam survey sites this includes: woody debris measurements; water depths; depths of fines; elevation; water chemistry; water temperature; fish surveys; QHEI surveys; and photographs.

Acknowledgments:
This project would not have been possible without the assistance of the GLREC and Indiana Dunes National Lakeshore, as well as GLISTEN (the Great Lakes Innovative Stewardship Through Education Network). Thanks to Dr. Charles Morris, Dr. Erin Argyilan, and Dr. Laurie Eberhardt for their support in the design and implementation of this project. Thanks to the logjam field crew for their dedicated work over the summer.

Budget: GLREC internship stipend, $2,500

Isle Royale National Park



Home Range of "Aralia", pictured below, as represented by minimum convex polygon, above.

Title: Radio Telemetry of American Marten at Isle Royale National Park

Report Authors/Affiliations: Erin and William Schlager, post undergraduates; Mark Romanski, Biologist, Isle Royale National Park

Project Summary:
Isle Royale National Park (IRNP) contains the only insular population of American marten (*Martes americana*) in the contiguous United States. Recent analyses suggest this isolated population is relict, and has genetic distinctness comparable to subspecies status (Romanski and Belant *unpublished data*). Intensive radio telemetry tracking of Isle Royale National Park's only radio collared American marten, "Aralia", occurred between September 1-28, 2012 with primary funding provided by the Great Lakes Research and Education Center. Nearly 150 hours of telemetry garnered 26 locations of the marten which were used to produce a minimum convex polygon (Mohr 1947) and k-nearest neighbor convex hull polygons (Getz and Wilmers 2004) in ArcGIS 10, to analyze the marten's home range and habitat utilization preferences within that home range. We used the on-line web application LoCoH (http://locoh.cnr.berkeley.edu) to conduct k-nearest neighbor analyses. Although no modeling data can be generated from the observations of a single individual, methods will be developed to form a template of potential models analyzing spatial representation and distribution of Isle Royale's marten population; essential data for addressing management unique and relict population of marten. The time and energy it took to effectively radio track one marten is also useful data in understanding the future efforts required to radio track even more martens should trapping occur in the future.

A total of 146.5 hours were spent radio tracking over a 28 day period. We collected 124 bearings, resulting in 26 successful locations for the month of September. Of the 26 locations, 16 were the result of triangulations, 9 were biangulations, and 1 was a quadrangulation. Error ellipses for locations varied from 1 m^2 to 264960 m^2. One location, with an error ellipse of 177225 m^2 was removed from the data set as a clear outlier, falling close to the north shore of the island. With the removal of this data point, the mean error ellipse was 28905 m^2 and the median value was 7705 m^2. The area of the marten's home range as calculated from the minimum convex polygon derived from the location dataset is 4.6 km^2 (See Above). This falls well within the average home range size of female martens which Clarke et al (1987) cites as 3 to 6 km^2 under the minimum area method.

In generating home range and utilization distribution with k-nearest neighbor convex hulls (k-NNCH), the value of k represents the total number of points from which local hulls are constructed, including the original point (Getz and Wilmers, 2004). Getz and Wilmers suggest good values of k should be around the square root of the number of data points. Both k-NNCH polygons for k=5 and k=6 contain significant "holes" within the home range. Getz and Wilmers suggest that at low k values, the smallest value of k that produces a covering that has the same topology as the given set (minimum spurious hole covering). At k=7, the minimum spurious hole covering value for k is obtained. While at k=10, the lowest k value that generates a minimum convex polygon is realized. Polygons from fixed-k analyses show that the marten's distribution is most highly concentrated in the southwestern portion of her home range (Figure 1).

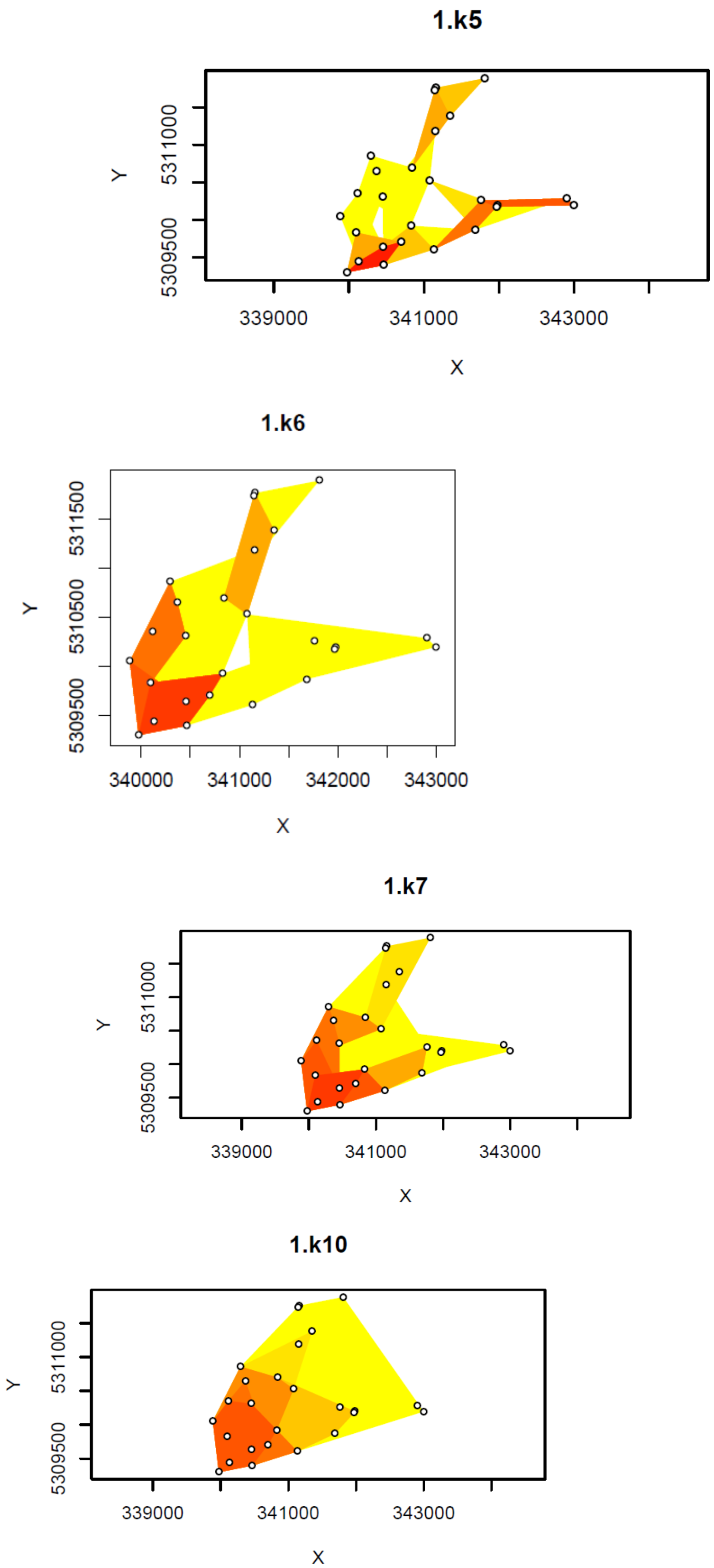


Figure 1. Home range and utilization distributions based off of the location data set using a fixed k-NNCH analysis. Red polygons indicate a higher density of use, while yellow indicates less dense or less frequented areas of use. K=10, bottom right, is the minimum convex polygon.

The vegetation types contained by the marten's home range encompassed 14 separate categories with relatively equal representations of conifer and deciduous classification (USGS 2000). Fifteen of twenty five location points occurred in the spruce-fir vegetation type, considered by Clarke et al (1987) as marten's preferred habitat (Figure 2).

Personnel Involved:
Mark Romanski, ISRO Biologist; Erin Schlager, GLREC Intern; Will Schlager, Volunteer

Products and Deliverables:
Products and deliverables for this work included a telemetry geodatabase and final report summarizing

Acknowledgements:
We would like to thank the Great Lakes Research and Education Center for providing the stipend to complete this work. Specifically, Joy Marburger, for providing us the opportunity and administrating the grant. We would also like to acknowledge the following Isle Royale National Park employees for their assistance in this project: Paul Brown, Katy Goodwin, Steve Martin,

Erin Grivicich, and Lucas Westcott. Finally, we are grateful to William Schlager, our co-author for volunteering over 80 hours in field work to help ensure this project was a success.

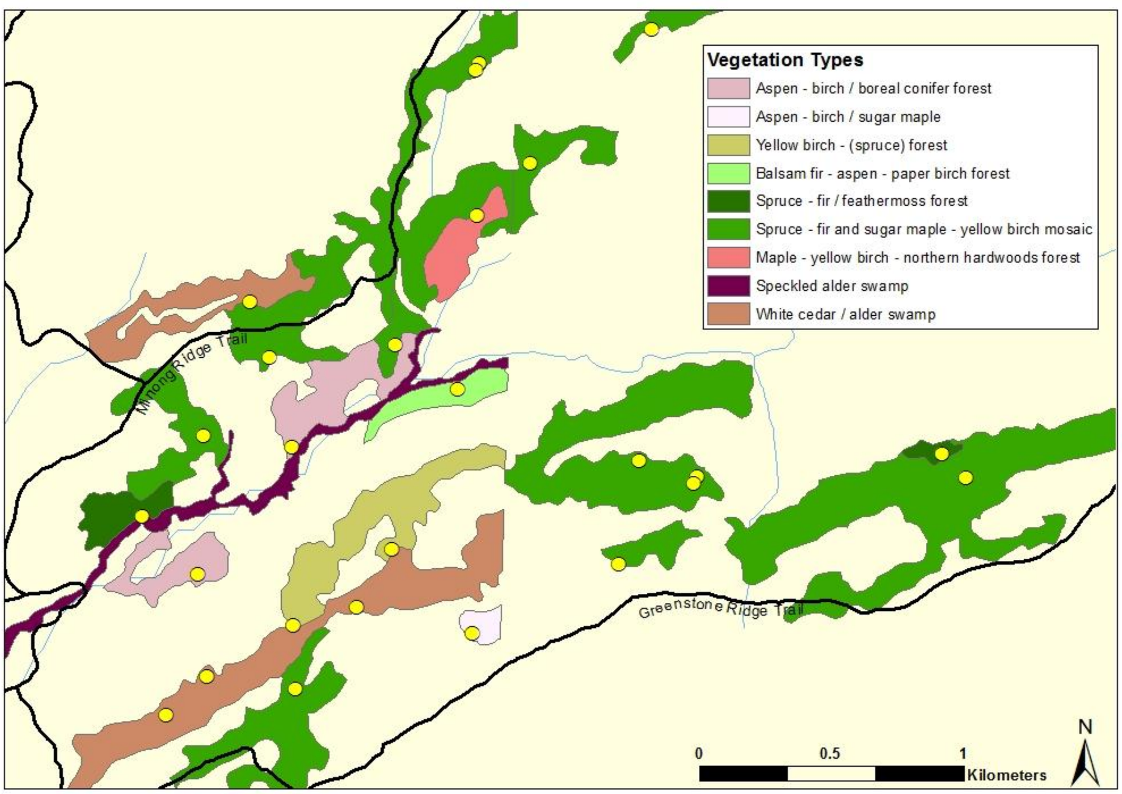


Figure 2. Vegetation types containing the location data set. The majority of which are contained within a Spruce-fir classification.

Budget: GLREC internship stipend, $2000; in-kind support from ISRO, $2,000.

Literature Cited:

Clarke, T., E. Anderson, C. Douglas, and M. Strickland. 1987. Martes americana. Mammalian Species. The American Society of Mammologist. Pg 1-8

Getz, W. and C. Wilmers. 2004. A local nearest-neighbor convex-hull construction of home ranges and utilization distributions. Ecography. Volume 27. Pg 489-505.

Mohr, C. O. 1947. Table of equivalent populations of North American small mammals. American Midland Naturalist 37:223–249.

US Geological Survey. 2000. Isle Royale National Park spatial vegetation data: cover type / association level of the National Vegetation Classification System. USGS, Biological Resources Division, Center for Biological Informatics, Denver, Colorado, USA.

Isle Royale National Park

Figure 1: GLREC Intern Eric Pomber on former Nippissing peninsula feature

Title: Where's the Beach: Phase I Archaeological Testing of the Nippissing Shoreline

Report Authors/Affiliations: Seth DePasqual, Cultural Resource Manager for Isle Royale National Park and Eric Pomber, MTU Student and 2012 GLREC Intern

Project Summary:
During the 2012 field season, NPS archaeologists undertook a Phase 1 archaeological survey of Isle Royale's Nippissing shoreline, a relict Lake Superior shoreline dating to approximately 5,000 years before present (ybp). The Nippissing shoreline is a contemporary of Archaic-period cultures, of which relatively little is known when compared with more recent prehistoric cultures on Isle Royale. Using GIS (including a 2004 LiDAR DEM) as a platform, coupled with conventional survey and testing methods, archaeologists tested the probability of locating early occupation sites along Isle Royale's Nippissing shoreline. This was a collaborative project undertaken by Isle Royale National Park and Grand Portage National Monument staff, a GLREC/MTU intern, and four Minnesota-based volunteers.

Primary survey efforts took place on the western side of the island in the Washington Harbor vicin**i**ty. Secondary surveys were performed on the east side, at locations surrounding Rock Harbor and Moskey Basin. Survey areas were preselected based on geographic orientation and/or proximity to water or potential sustenance areas. Futhermore, site settings from more recent cultures were applied to those along the Nippissing. Over 400 shovel test pits were dug resulting in the discovery of seven new archaeological sites. One site in particular yielded a copper chisel, a rare find considering the limited size of the test units. Based on the recovered materials, and their association with the Nippissing shoreline, we presume these to be related to Archaic period cultures. Further research is still necessary, although the results are encouraging.

Background:
Isle Royale's Nippissing shoreline is one of the most prominent relict shorelines found on the remote island archipelago. Resting 14m (approx. 46') above today's modern shoreline, the Nippissing was active approximately 5,000 years before present (ybp). Now high and dry and sometimes well inland, it reflects a dramatically different island landscape with its own unique inventory of islands, bays and peninsular features. Numerous relict shorelines trace themselves across the archipelago including those much older than the Nippissing (Huber, 1986). The Minong for example, rests 22m (approx.72') above today's shoreline and was active 10,700 ybp. What distinguishes the Nippissing however is its association with the first known human endeavors on Isle Royale. That is, the Nippissing version of Isle Royale was active when the first canoe reached its shores.

Most of what we know about island prehistory derives from activities that took place along the island's present coastline (Clark, 1995). These activities were associated with Woodland cultures, the earliest appearing in the region approximately 3,000 ybp, when ceramics are first seen in the artifact assemblages. Subsequent Woodland cultures took the form of many groups and continued into the Euroamerican contact period. The island's archaeological inventory reflects many of the activities associated with such groups. Yet relatively little is understood about the earlier Archaic-period cultures on Isle Royale. This culture (specifically late-Archaic) was likely the first to have visited the island. However, related peoples would not have encountered today's shoreline as it was then submerged. Instead they would have been greeted by the Nippissing beachhead, which today rests uphill and inland from the island's modern shoreline.

Beginning approximately 4,500 years ago the first island visitors experienced an archipelago quite different than the one we know and see today. Vegetation and faunal assemblages varied somewhat from those found in modern times but they still reflected a southern boreal biome. Less subtle were the differences between the coastlines of then and now. The Nippissing shoreline, which probably met the island's first canoe landing, featured a completely different series of bays and peninsulas. These same features, through time and a combination of rising landmass (isostatic rebound) and receding lake levels, have taken on new appearances that stray far from that witnessed five millennia ago (Blewett, 2009). The bays are now inland, either dry (innocuous valley floor or swampland) or landlocked (Feldtmann and Halloran lakes). The peninsulas have become inland hills or resemble elongated versions of their former selves. At first glance these features seem nondescript, resembling many other island locations found inland. Given further scrutiny, one will notice distinct terrace-like features, sometimes cascading down a forested hillside. These terraces are in fact beachheads, relicts of a previous Lake Superior shoreline. More importantly, these terraces would have served as occupation sites, much like today's beachheads where more recent archaeological settings were situated.

Methodology:
The terraces mentioned above are unique in that they are often level, providing ideal conditions for human habitation. Some would have been more exposed, bearing the brunt of Lake Superior winds and storms. Others were likely more protected, sometimes offering expansive views of the lake or perhaps an inland valley. Recognizing these differences, NPS archaeologists scrutinized detailed topographic imagery (2004 LiDAR) selecting survey polygons where conditions seemed ideal. Washington Harbor was deemed a good starting place primarily based on the region's expansive soils relative to the Island's eastern side where bedrock is often more prominent. Moreover, the west side of the island featured an interesting collection of bays, peninsulas and inland drainages associated with the Nippissing. Like all island research endeavors, logistics weigh heavily on related considerations. The Windigo Ranger Station afforded housing, convenient boat transportation and a centralized location to many of the survey polygons. Even further, Washington Harbor is relatively protected, allowing survey work to continue in the event of inclement weather when boat operations were discouraged.

The survey team was divided into two groups so that efforts could be made in multiple survey polygons. Each team utilized a Trimble GeoXT GPS receiver featuring shapefiles of the survey polygons and Nippissing shoreline. Using these GIS layers, survey crews were able to put themselves into exact positions atop Nippissing beach terraces. Once in the survey polygon, crews then assessed ground conditions, allowing local geography to dictate testing strategy. The survey employed a shovel testing procedure, where shovel test pits (STPs) were sunk on the terrace/bench tops in an effort to locate archaeological settings. The STPs were 30cm in diameter and varied in depth. Since many of the island's archaeological settings are located within the top 30cm of soil (all cultures), most of the STPs dug during the survey ventured no further than 50cm in depth. However, the first few STPs made in a new survey polygon were sometimes dug deeper to assess the soil profile for the area. STPs were usually spaced within 10m of one another. Sometimes local conditions required larger distances. If an STP proved positive, subsequent

STPs were dug in the four cardinal directions. These STPs were spaced 5m from the original find. All told, 385 STPs were dug during the Washington Harbor survey (May, 2012). Twenty-four STPs were later dug during the Rock Harbor Survey (July/August, 2012).

Results:

The 2012 Relic Shoreline Survey yielded 7 new archeological sites. All were located on the west side of the island in the Washington Harbor vicinity. Six of these sites are prehistoric, the other historic. The six prehistoric sites were found in five separate survey polygons. All were found above the Nippissing shoreline, which may be indicative of an Archaic period culture. The artifacts are primarily comprised of lithic waste material related to the production of stone tool implements. Most of this lithic material is non-native to Isle Royale suggesting import via human carrier. Beyond material type and origin, no diagnostic evidence was noted on the lithic material.

Two copper implements were identified in two separate survey polygons. The first was a small, unworked copper nugget. It appears to be in natural form as no obvious markings or modifications were noted on its surface. However, its association with lithic materials found at the same location suggests that it may indeed be cultural. The second copper item was a small, 6 cm chisel that features obvious edges and a sharp working end. It was likely implanted within a bone or wooden handle. The chisel exhibits a black strip of what appears to be a hardened organic material. This may be natural or it could possibly be related to the tool's manufacture or use. Isle Royale is currently seeking input from regional professionals on this issue. If the material can be identified, it may be dateable. If so, there exists the chance of accurately dating the site thus establishing a likely cultural affiliation.

The single historic site is best described as a small prospect pit and resembles those found in association with a number of island-based mining locations. However, the placement of the feature is quite different in that virtually no bedrock exists at the location.The soils at this particular site are deep and there is no indication of a bedrock source anywhere nearby. Since the pit is miles from the nearest historic mining context, its true origin remains a mystery.

Three separate survey polygons were tested in Rock Harbor vicinity with negative results. This side of the island features many bedrock exposures when compared with the Washington Harbor survey area. Shovel testing here is often difficult as the soils are often shallow and sometimes non-existent.

Conclusions:

In sum, the Relic Shoreline Survey proved successful. Seven new sites were located and six are likely associated with early island habitation. Prior to the 2012 survey, only seven Archaic-period sites had been confirmed. If indeed Archaic, the 2012 discoveries are significant in that they add to our limited understanding of early island use and occupation. The finds are small, but they hint of something larger resting undisturbed at each location. It is our intent to continue research efforts at some of the new sites in 2013.

Furthermore, the discoveries confirm the value of the methodologies used. These methods are far from novel, yet they now benefit from Digital Elevation Models (DEMs) such as LiDAR. This particular DEM allows us to query and analyze accurate elevation values so that the Nippissing can be traced island-wide. When this is done with confidence, archaeologists can better calibrate their findings with respect to more recent island cultures.

Personnel Involved:
Seth DePasqual: Cultural Resource Manager, Isle Royale National Park
Bill Clayton: Cultural Resource Manager, Grand Portage National Monument
Stephen Veit: Museum Technician, Grand Portage National Monument
Eric Pomber: GLREC intern and Michigan Technological University student
Randy Beebe: Volunteer
Caleb Cowden: Volunteer
Sam Olson: Volunteer
Lou Hohertz: Volunteer

Products and Deliverables:
Seven new sites were located and six are likely associated with early island habitation. Prior to the 2012 survey, only seven Archaic-period sites had been confirmed. If indeed Archaic, the 2012 discoveries are significant in that they add to our limited understanding of early island use and occupation. The finds are small, but they hint of something larger resting undisturbed at each location. It is our intent to continue research efforts at some of the new sites in 2013.

The discoveries confirm the value of the methodologies used for mapping the sites. These methods are far from novel, yet they now benefit from Digital Elevation Models (DEMs) such as LiDAR. This particular DEM allows us to query and analyze accurate elevation values so that the Nippissing can be traced island-wide. When this is done with confidence, archaeologists can better calibrate their findings with respect to more recent island cultures.

Budget:
GLREC Internship Stipend for MTU Intern Eric Pomber $2,000

Acknowledgements:
GLREC for supporting MTU intern Eric Pomber.
GRPO Superintendent Timothy Cochrane for supporting the ISRO/GRPO collaboration.

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Clark, Caven P. *Archaeological Survey and Testing, Isle Royale National Park, 1987-1990 Seasons*. Edited by F.A. Calabrese. Midwest Archaeological Center Occasional Studies in Anthropology no. 32, 1995.
Huber, Norman K. *The Geologic Story of Isle Royale National Park.* Revised by Isle Royale Natural History Association in cooperation with the National Park Service and the Geological Survey. Houghton, MI. 1986.

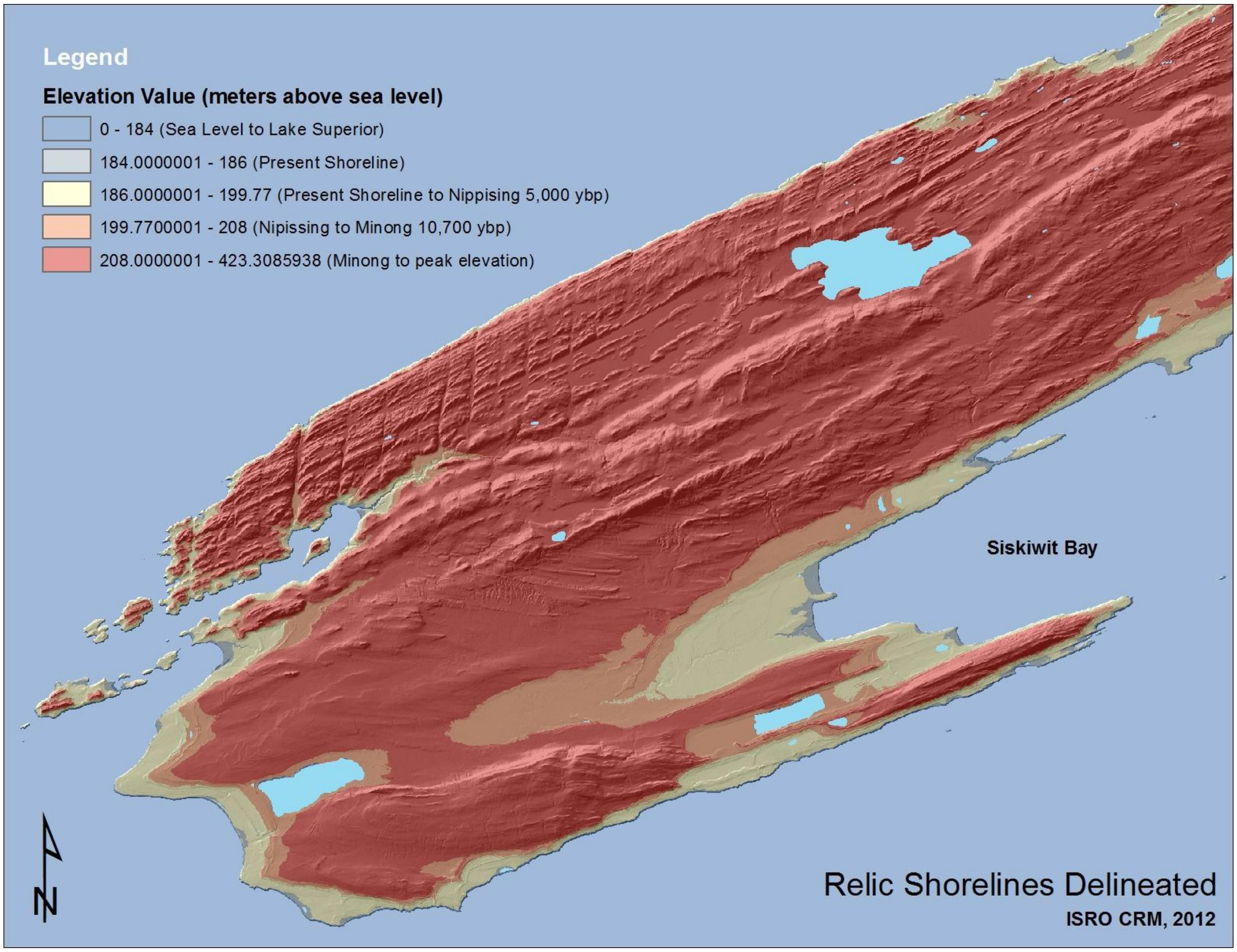


Figure 2: Overview map of Isle Royale West showing LiDAR-based topography and major shoreline fluctuations. The target shoreline (Nippissing) is represented by the exterior side (lake side) of the pink layer. This is essentially the seam line between the beige and pink layers. The Minong shoreline begins where the pink meets the red.

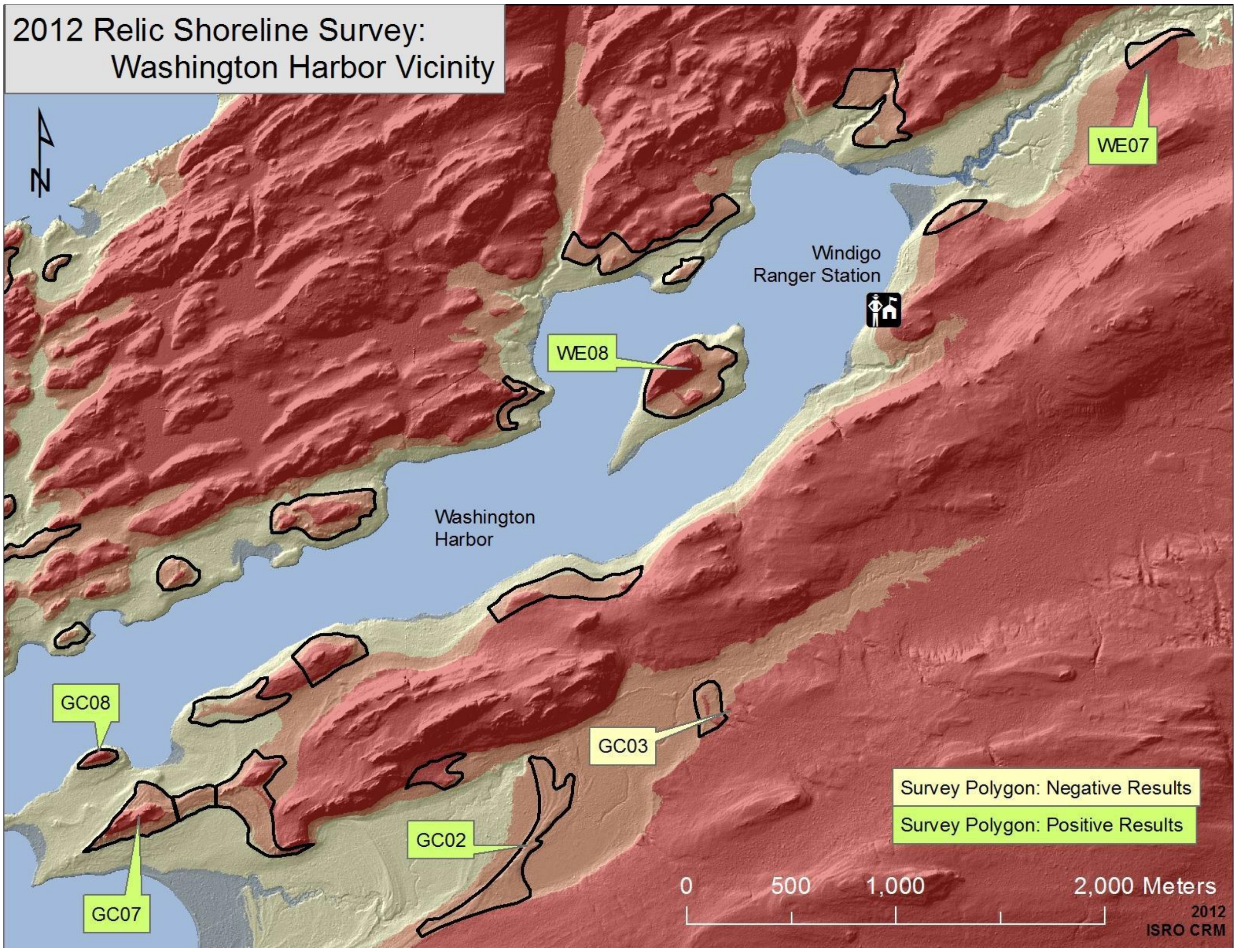


Figure 3: Overview of Washington Harbor survey area. Survey polygons were drawn with attention to Nippissing shoreline features such as former peninsulas (GC07), islands (WE08/GC08) and spits (GC02). Long featureless shorelines were generally avoided.

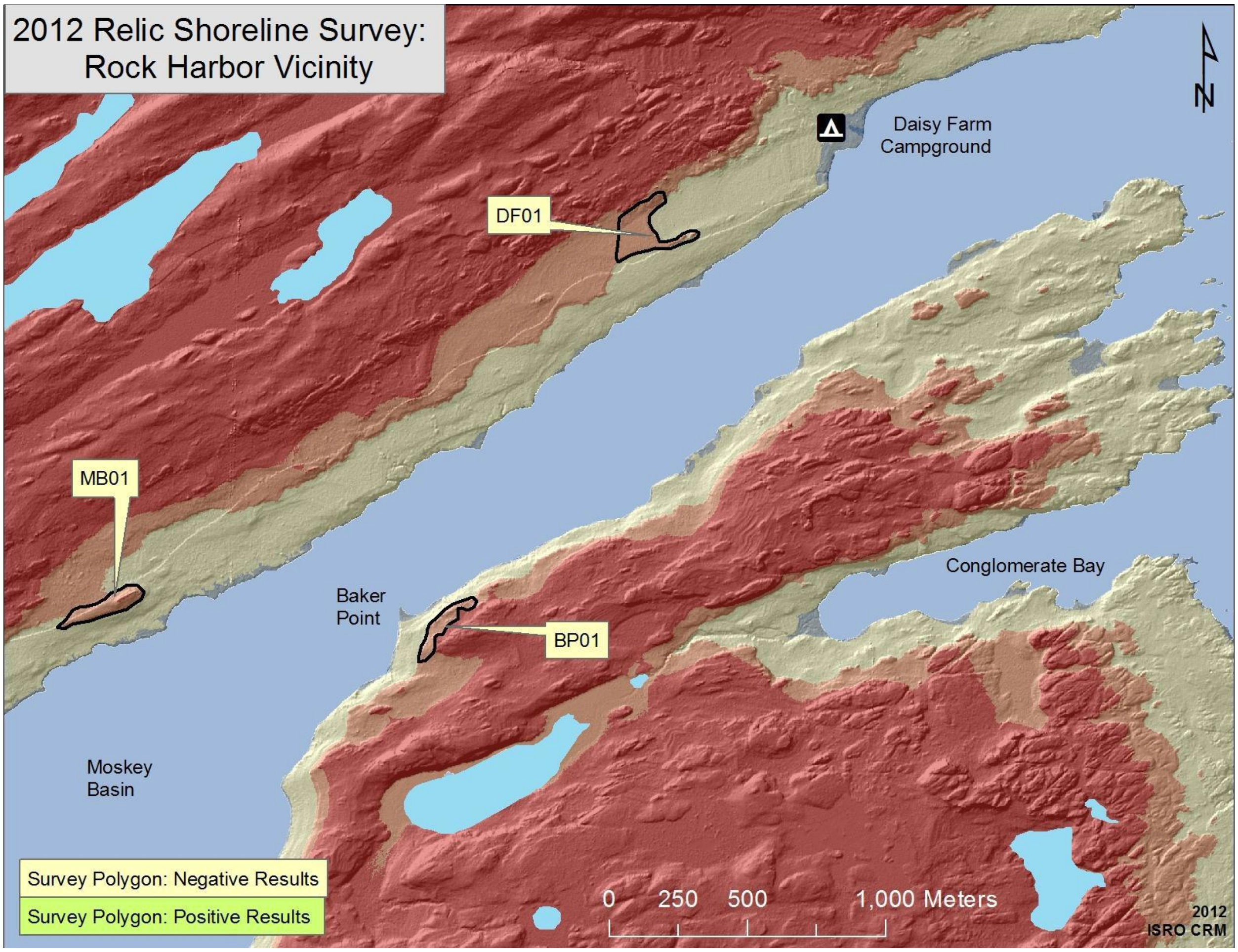


Figure 4: Overview of Rock Harbor West survey area. Sediment deposition here is less extensive than that found on the west side of the island. This translates to more bedrock exposures (see Figure 1), which inhibits shovel testing efforts. Deep beach soils do exist, but are harder to come by.

Figure 5: Copper chisel. Black strip of organic material at left.

Figure 6: Scraper tool, Hudson Bay Lowland Chert

Figure 7: Core shatter (HBLC). Cortex not shown.

Figure 8: Tertiary Flake,

Voyageurs National Park

Radio-collared moose cow and calf in forest opening

Title: Investigations of the Effects of Climate Change on Moose in Voyageurs National Park

Report Authors/Affiliations: Bryce Olson, GLREC Intern and M.S. student at Bemidji State University, David Morris (Lakehead University), and Steve Windels (VOYA)

Project Summary

The threat of climate warming suggests that a northerly shift in the distribution of moose, among other species, is imminent, threatening populations in northern Minnesota and parts of northwestern and central Ontario. Generally, populations occupying the southern extents of their ranges are at particular risk from climate warming, where daily and seasonal weather conditions are likely to begin exceeding tolerable temperature ranges for moose. Moose can mitigate the effects of high ambient temperatures on their heat balance through behavioral or physiological mechanisms. Voyageurs National Park (VOYA) is already investigating several of the behavioral mechanisms, including how moose use forests and beaver-created wetlands in relation to temperature and weather extremes. Moose also likely moderate their internal temperature through contact with the ground while bedding. The amount of heat that can be dissipated will depend on many factors but may primarily be driven by the characteristics of the soil surface and subsurface, such as thickness of duff layer and soil-moisture conditions. Funds provided by the 2012 GLREC Assistance Request were used to support several students working on studies related to the effects of climate change on boreal systems and the implications for moose, a species in decline.

Effects of Climate Change on Beaver-Created Wetlands: Implications for Moose at the Southern Edge of Their Range

Habitat availability for the North American moose (*Alces alces*) may be altered due to climate change. Increased knowledge of how aquatic patch selection by moose varies with ambient temperature is desirable, particularly since rising temperatures have been correlated with the decline of moose in some areas of North America, including northern Minnesota. The direct thermoregulatory benefits of aquatic patches to moose are being evaluated in this study. Because moose management guidelines often recommend selection of potential moose aquatic feeding areas according to their ability to provide submergent aquatic plants as food for moose, the capacity of these feeding areas to provide moose forage will also be investigated. Thus, aquatic patches could serve to reduce energy expenditure for thermoregulation while simultaneously acting as important feeding patches for moose, but it is not clear whether moose primarily use aquatic patches to cool down, feed, or both. The proposed research project will quantify the thermal and aquatic foraging environments of aquatic patches that vary with patch size, age, and other factors in order to develop a predictive model of moose aquatic patch use near the southern periphery of their range. The model will emphasize thermoregulation and aquatic foraging and may be used to improve identification of moose aquatic feeding areas in North America and model changes to the spatio-temporal mosaic of suitable aquatic patches for moose in response to climate change.

In 2012 we measured temperature profiles and aquatic plant communities in 18 beaver- created wetlands (impoundments) and 6 lake bays (Figure 1). Sites were selected using a random stratified design for size and age (pond only). Temperature profiles at 50 and 150cm depth in the water column were measured using HOBO WaterTempPro_v2 temperature loggers (Figure 1).

We also measured temperature in the upper 10 cm of the substrate (i.e., muck). Submergent and floating-leaf vegetation (i.e., those most often consumed by moose and beavers) were measured at 20 random locations in each pond using a modified rake technique (Figure 1).

Biomass regressions were developed to convert rake scores to biomass. Vegetation sampling was completed for all sites twice to cover the early (May-July) and late (July-September) period of plant phenology. Some preliminary results were presented at the 7th International Moose Symposium in Poland in August, 2012 (Appendix 1).

Figure 1. (Upper Left) Typical beaver pond in Voyageurs National Park. Floating leaf vegetation (water shield) is visible as light green patches. (Upper Right) MS Student David Morris and George Melendez Wright Climate Change Intern Samantha Hasek sample aquatic vegetation from a rubber raft in a pond. (Left) David Morris standing next to a deployed temperature logger.

Thermal Characteristics of Moose Bedsites

Voyageurs National Park initiated a study of the thermal characteristics of moose bedding sites in 2012 in collaboration with the Minnesota Zoo and University of Minnesota-Duluth. Fine scale movement data from GPS collared moose in VOYA was used to identify moose bed site locations in 2011. These locations were used to characterize the vegetation, soils, and topographical features of moose bed sites in summer (Figure 1). Vegetation characteristics included general association type (plant community type) and percent canopy cover which was determined using fisheye hemispherical photography. Understory vegetation was described using a combination of percent area cover estimates, height measurements and cover board density estimates. Basal area was also recorded allowing recommendations to be made to forest managers. Soils were analyzed using multiple thermal property logging instruments (Decagon Devices Inc.) as well as soil horizon types and depths. A soil core (figure 2) was also collected allowing further analysis of soil properties (e.g. percent organic content). Topographical information recorded at bed sites included percent slope and aspect. To determine soil temperature fluctuations over the summer study period, a HOBO Pendant (Onset Computer Corporation) temperature logger was placed in the soil and retrieved at the end of the study period. An additional set of moose bed sites were selected from recent (1-3 days) bedding events using uploaded satellite locations from VOYA moose in 2012. These “realtime” bed sites were characterized in a similar fashion to the 2011 bed sites with the addition of measurements of the moose body impression on the vegetation and soil (Figure 3).

Figure 2. (Upper Left) Data collection at 2011 moose bedsite by M.S. Student and VOYA biological science technician Bryce Olson. (Upper Right) A recent (<24 hours) moose bedsite detected using the real-time GPS collars. (Left) Soil core sample collected at real-time moose bedsite.

Data was also collected from GPS-collared moose in another study area in northeastern Minnesota for comparison. Information about moose bed-site characteristics will be useful for land managers to assess the impacts of various treatments or habitat disturbances to mitigate potential impacts of climate change on moose and other boreal forest species. This project also builds upon concurrent work by M.S. student Bryce Olson (and previous GLREC assistance recipient) describing the thermal environment for moose in Voyageurs National Park.

Personnel Involved:

Effects of Climate Change on Beaver-Created Wetlands: Implications for Moose at the Southern Edge of Their Range

- Students
  - David Morris – M.S. Student, Lakehead University
  - Samantha Hasek – George Melendez Climate Change Intern (Northern Michigan University)
  - Hugo Pierre – M.S. Student, AgroParis Tech (France)
- Other Personnel

- Steve Windels, Wildlife Biologist, VOYA; adjunct professor, Lakehead University & University of Minnesota-Duluth
- Ron Moen – Research Associate, University of Minnesota-Duluth/NRRI
- Nick McCann – Post-Doctoral Fellow, Minnesota Zoo
- Brian McLaren – Associate Professor, Lakehead University

Thermal Characteristics of Moose Bedsites

- Students
  - Bryce Olson – M.S. Student, Bemidji State University; seasonal biological science technician, VOYA
  - Samantha Hasek – George Melendez Climate Change Intern (Northern Michigan University)
- Other Personnel
  - Steve Windels, Wildlife Biologist, VOYA; adjunct professor, Lakehead University & University of Minnesota-Duluth
  - Ron Moen – Research Associate, University of Minnesota-Duluth/NRRI
  - Nick McCann – Post-Doctoral Fellow, Minnesota Zoo

Products and Deliverables

Thermal and Vegetative Attributes of Aquatic Patches Available to Moose in Northern Minnesota, USA. David M. Morris, Jr., Steve K. Windels, Brian E. McLaren, Ron A. Moen, and William J. Severud. 2012. Poster Presentation. 7th International Moose Symposium, Bialowieza, Poland.

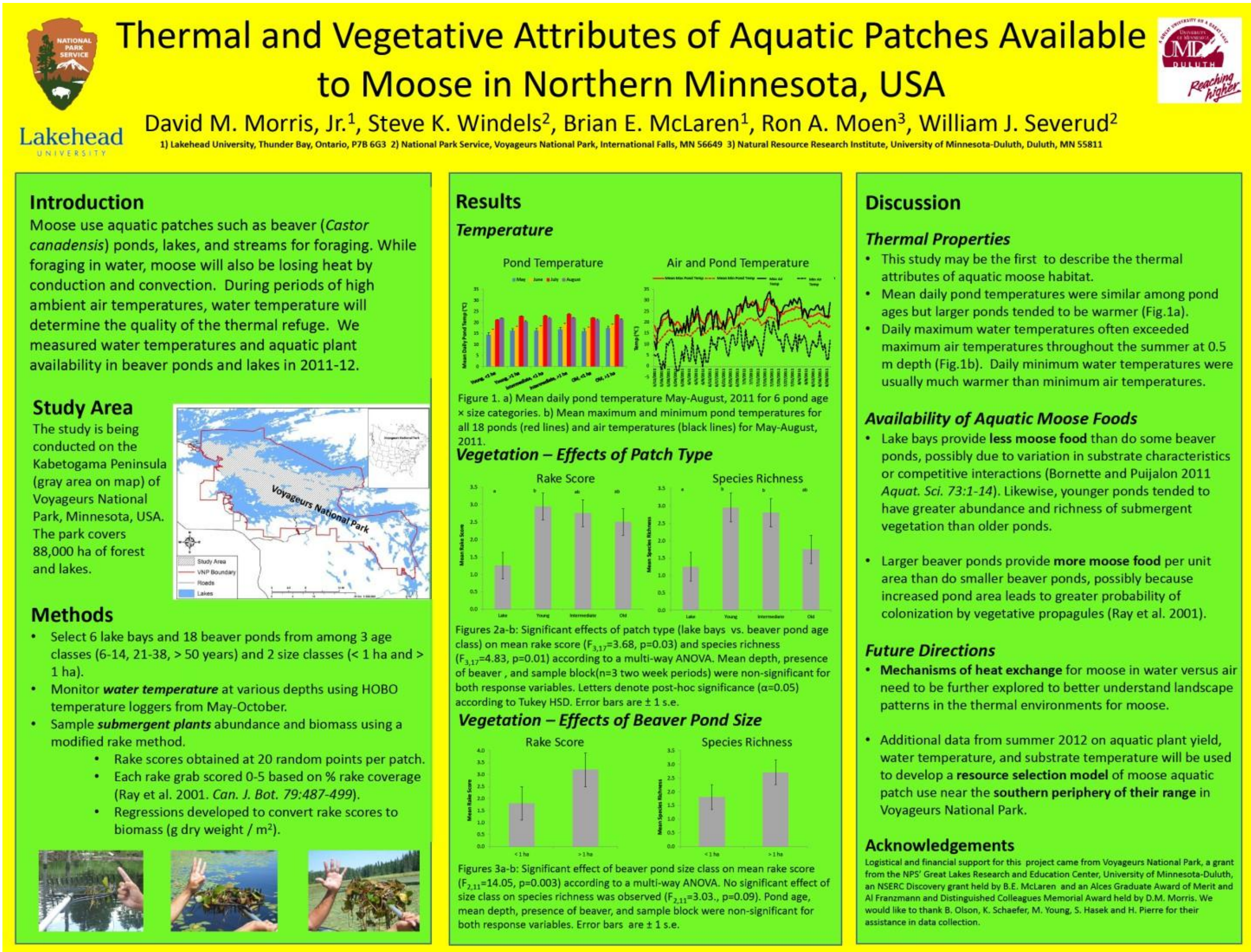
Characteristics of the Thermal Landscape for Moose at Voyageurs National Park, USA. Bryce T. Olson, Steve K. Windels, Ron A. Moen, and Mark R. Fulton. 2012. Poster Presentation. 7th International Moose Symposium, Bialowieza, Poland.

Budget: GLREC internship stipend, $2,250; in-kind from VOYA, $2,000

Acknowledgements:

We would like to thank Bill Severud, Lisa Maass, and Raphael Gelo (VOYA) for additional field assistance. Supplementary funding for these projects was provided by Voyageurs National Park, Lakehead University, a Discovery Grant held by Brian McLaren, University of Minnesota-Duluth, and the Minnesota Zoo.

Appendix 1. Poster presentations that highlighted GLREC supported work in 2012.



Characteristics of the Thermal Landscape for Moose at Voyageurs National Park

Bryce Olson (1, 3), Steve Windels (1), Ron Moen (2), Mark Fulton (3)

1) National Park Service, Voyageurs National Park, International Falls, MN 56649 2) Natural Resource Research Institute, University of Minnesota Duluth, Duluth, MN 55811 3) Bemidji State University, Bemidji, MN 56601

INTRODUCTION

Recent scientific and anecdotal evidence suggests moose (*Alces alces*) populations in Minnesota are declining due to a combination of factors including disease, parasites, and habitat and climatic changes. Moose may respond to warm temperatures by physiological and behavioral mechanisms (e.g., panting or selection of cool habitats). The ability of habitat selection to reduce heat load requires variation in the thermal environment. The thermal environment of moose can be described using operative temperature which combines convective and radiant heat fluxes into a single metric and is most easily measured using black globe thermometers (Fig. 1). Black globe temperatures (BGT) were recorded in Voyageurs National Park (VNP; Fig 2.) to understand the response of moose to temperature and weather events in northern Minnesota, the southern extent of their range.

Project objectives:

•Measure and compare microclimate BGT across a range of possible predictors, including vegetation community, canopy cover, and slope/aspect to describe the thermal environment of moose in VNP.

•Develop spatially and temporally-explicit models of BGT during select periods allowing prediction of BGT in moose locations in VNP.

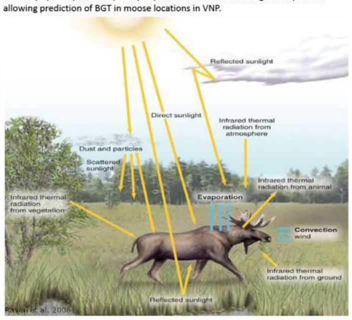


Figure 1. Mechanisms of heat exchange between a moose and its environment. Note: conduction is not included in this figure.

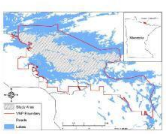


Figure 2. Location of Voyageurs National Park, MN, USA. The Kabetogama Peninsula study area is highlighted in gray.

METHODS

- Black globe temperatures were collected from 94 loggers at 15 minute intervals for one full year (Fig.3).
- Placement of loggers was stratified by landscape and vegetation characteristics developed using remote sensing techniques.
- Weather data were collected at local meteorological stations.
- Radiation was modeled using the Solar Radiation Extension in the Spatial Analyst toolbox in GIS and filtered by cloud attenuation factors from corresponding cloud cover categories.
- Seasonal BGT characteristics were analyzed using repeated measures ANOVA with Bonferroni post-hoc comparisons.

Figure 3. Cross-section and attached black globe thermometer showing Hobo U22 Water Temp Pro v2 temperature loggers inserted into a 15cm diameter copper toilet bowl float painted matte black. Loggers were hung 0.75m above ground 15cm from trunk on NE side of tree.

- Regression models of operative temperature were created for a two week period assumed to be thermally stressful to moose (July 1-14, 2010). Operative Temperature (T_e) was modeled using the equation:

$$T_e = T_a + \frac{R_{abs} - \varepsilon_s \sigma T_a^4}{c_p(g_r + g_{Ha})}$$

where T_a is the ambient air temperature (C°), R_{abs} is the solar and thermal radiation absorbed by the globe (W m^{-2}), $\varepsilon_s \sigma T^4$ is the thermal emittance (W m^{-2}) on the surface of the globe at T_a (K). The $c_p(g_r+g_{Ha})$ term in the denominator consists of the specific heat of air (c_p), radiation conductance (g_r), and boundary layer conductance (g_{Ha}).

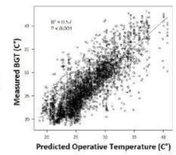
- Model of best fit was selected using Akaike Information Criterion.

RESULTS

Table 1. Factors affecting mean daily operative temperature in Voyageurs National Park across seasons. We also analyzed separately for the afternoon period (1-4 p.m.), generally the hottest part of the day. Significance indicated at P<0.1 (*), P<0.05 (**) and P<0.001 (***).

Season	Time of Day	Vegetation Cover Type	Percent Canopy Cover	Slope/Aspect
Spring	Day			
	Afternoon	*		**
Summer	Day	**	*	
	Afternoon	***	**	
Fall	Day			
	Afternoon	**		
Winter	Day			*
	Afternoon	*		***

Figure 4. Comparison of measured BGT (C°) and model predicted operative temperature for July 1-14, 2010.



DISCUSSION

- Cover type, canopy cover, and slope/aspect all significantly influenced black globe temperatures, although differently depending on season and time of day (Table 1).
- Spatial models of operative temperature in VNP predicted a range of greater than 10 C° across the landscape during the afternoons of July 1-14, 2010 (Figures 4, 5).
- These models demonstrate fine-scale patterns of operative temperature that may influence habitat selection and behavior of moose under extreme temperature events.

FUTURE DIRECTION

The models developed will also be used to test predictions about how moose behave in response to their thermal environment. Nineteen moose fitted with GPS collars containing activity counters in VNP have been capturing fine scale movements and patterns of activity (e.g. resting, moving) since 2010. Locations of an additional six moose wearing GPS collars in the years 1995-1997 will also be compared to the back-calculated thermal environment using the BGT models.

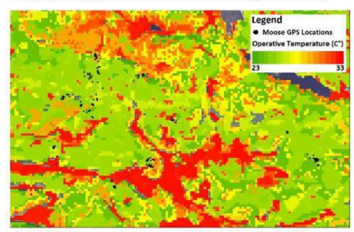


Figure 5. Modeled operative temperature (C°) in a selected area of Voyageurs National Park during the afternoon hours of July 1-14, 2010. Moose locations from GPS collars from the same period are also shown. Pixel size is 30m x 30m.

ACKNOWLEDGEMENTS

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